

Remarks/Arguments

Applicant thanks Examiner Le for his patient and careful examination of this application and for the clear explanation of the claim rejections. In response to the Office Action of April 24, 2006, applicant replies as follows:

Claim 1

The Office Action rejects claim 1 under 35 U.S.C. 102(e) as being anticipated by US 6,770,547 to Inoue et al. Applicant respectfully submits that the rejection is improper because Inoue fails to disclose all the claim elements in claim 1.

Claim 1 describes a interconnect structure that includes a substrate, conductive contact pad, a compliant layer, and an insulation mask. The conductive contact pad includes an inner portion and an outer portion. The outer portion completely surrounds the inner portion. The compliant layer is disposed under the contact pad, with an elastic modulus lower than that of the contact pad. The inner portion of the contact pad covers the compliant layer and is thinner than the outer portion, which does not cover the compliant layer. The insulation mask is disposed over the contact pad with an opening that exposes the inner portion of the contact pad.

The Ground of Rejection

The Office Action states that:

Regarding claim 1, Inoue discloses an interconnect structure in fig. 30 comprising: ...a conductive contact pad 4, ...having an inner portion 4 and an outer portion 4/7 (layer 4 in contact pad 7 in fig. 21), the outer portion 4/7 of the conductive contact pad completely surrounding the inner portion 4 of the conductor pad...

The Inoue patent

The Inoue patent directs to a semiconductor apparatus in which flip chip bonding is enabled without any underfill.¹ The elements cited in the Office Action

¹ US 6,770,547, Abstract.

as anticipating the claim elements in claim 1 are element 4 and element 7. The Inoue patent discloses element 4 as a redistribution wire:

[A] redistributing wire 4 is made of an electrical conductor such as copper. The redistributing wire 4 connects the aluminum pad 7 to a protrusive electrode such as a bump pad 3 on a surface of the stress relaxation layer 5.²

From this description, element 4 is a redistribution wire that connects an aluminum pad to a bump pad. This is clearly depicted in figs. 26b and 27. Other illustration of the redistribution wire are in figs. 11, 12, 14, 15, 16, 17, 20, 21, 22, 23, 24, etc.

The Inoue patent describes the aluminum pad 7, which is also depicted in all the figs. cited above, as follows:

Each semiconductor device 13 has an external connection terminal such as an aluminum pad 7. The aluminum pad 7 on which a gold wire or the like is connected is used for electrical connection to an external terminal of a semiconductor package such as a QFP (quad flat package) when the conventional semiconductor device 13 is encapsulated in a semiconductor package.³

Given the clear description of the element 7 as an aluminum pad and element 4 as a copper redistribution wire, and given the clear depiction in the drawing figures, any person skilled in the art of semiconductor device manufacturing would know that the aluminum pad does not surround the inner portion 4 of the conductor pad, as argued in the Office Action.

Because the Inoue patent clearly does not disclose all the claim elements in claim 1, applicant respectfully submits that the 102(e) rejection against claim 1 is improper and claim 1 stands patentable over the Inoue patent.

Claims 3, 4, 6, 8, 9, 10, 11, 28 and 29

² Ibid, col. 7, ll. 49-52.

³ Ibid, col. 5, ll. 49-55.

Claims 3, 4, 6, 8, 9, 10, 11, 28 and 29 properly depend from claim 1 with additional claim limitations. Applicant respectfully submits that because claim 1 stands patentable, claims 3, 4, 6, 8, 9, 10, 11, 28 and 29 stand patentable at least by virtue of their dependence.

Claim 30

Claim 30 describes a semiconductor device that includes a substrate, a conductive contact pad, and a compliant layer. The contact pad has an inner portion and an outer portion, each has a thickness; the inner portion is thinner than the outer portion. The inner portion is enclosed by the outer portion. The compliant layer is disposed directly under the contact pad, covered by the inner portion of the contact pad and it contacts the outer portion of the contact pad.

The Ground of Rejection

The Office Action rejects claim 30 under 35 U.S.C. 102(e) as being anticipated by US 6,552,563 to Yaniv et al.; and under 35 U.S.C. 103(a) as being unpatentable over US 5,508,228 to Nolan et al. in view of US 6,919,264 to Brintzinger.

The Yaniv patent

In rejecting claim 30 over the Yaniv patent, the Office Action argues that:

Regarding claim 30, Yaniv discloses a semiconductor device in fig. 8 comprising a substrate 100; a conductive contact pad 626/620...having an inner portion 626 and an outer portion 626/620, the inner portion 626...; a compliant layer 624 ... disposed directly under the contact pad 626, ...and contacting the outer portion 626/620 of the contact pad.

The Yaniv patent discloses an interface device for testing flat panel displays that includes a compliant bumps structure, which the Yaniv describes as follows:

Wire bond pad 620 is a portion of the electrical pads coupling compliant bumps 201 to driver chips 102. Polymer bump 624 attaches to

wire bond pad 620. Gold metallization layer 626 covers both polymer bump 624 and may cover at least a portion of bond pad 620.⁴

The description and the drawing figure 8 make it very clear that the polymer bump is attached to the pad layer 620 and the top and the sides are covered with a gold layer 626; and the gold layer 626 further contacts the pad layer 620 away from the polymer bump. Therefore, a bottom of the polymer bump contacts the pad 620, and the top and side portion of it contact the gold layer 626. In other words, the entire surface of the polymer bump contacts a single layer of metal, either the 626 layer or the 620 layer, but not both. And applicant respectfully submits that there is no evidence in the Yaniv patent that supports the argument in the Office Action that the compliant layer contacts the outer portion of the contact pad.

Because the Yaniv patent does not disclose all the claim elements of claim 30 of this application, applicant respectfully submits that it does not anticipate claim 30 and claim 30 stands patentable over the Yaniv patent.

The Nolan patent

Claim 30 stands rejected over the Nolan patent. The Office Action set forth the ground for rejection as follows:

"Regarding claim 30, Nolan discloses a semiconductor device in fig. 3 comprising...a conductive contact pad 26... having an inner portion (top layer) and an outer portion (bottom and side wall),a compliant layer 24 ...disposed directly under the contact pad, covered by the inner portion of the contact pad and contacting the outer portion of the contact pad."

The Office Action goes on to say that "Nolan does not expressly disclose the thickness of the outer portion is greater than the thickness of the inner portion. However, Nolan discloses the inner portion 26 is approximately as show in fig. 8 thinner than the outer portion and that the thickness of layer 26 can be adjusted to

⁴ US 6,552,563, col. 4, ll. 3-7.

created an effective modulus of the pad,....Accordingly, it would have been obvious to use the teaching Nolan in the range as claimed...."

The Nolan patent describes the gold metallization layer 26 in the following paragraph, which includes the citation in the Office Action:

FIG. 6e shows the result of the preferred process of electrolessly forming layer 60 of electroless gold on nickel layer 54 and polymer bump 24. The particular photo-resist in the present embodiment is chosen to resist activation. As a result, electroless gold only plates to the electroplated nickel 54 and polymer bump 24. Another possible technique for performing the step of FIG. 6e is to mix a catalytic powder with polymer before it is coated and the bump is formed. This powder would initiate electroless plating as a means for metallization.⁵

* * *

FIG. 6f shows the results of the next step of electroplating gold layer 62. Gold is electroplated to form layer 62, using a commercially available bath, to a thickness desired for wire bonding at a current density of approximately 8 amps per square foot, depending on the application. The combination of gold layer 62 and layer 60 form metallization layer 26 of FIGS. 2 through 4. Note that the plating rate on polymer bump 24 will be four to six times slower than the plating rate on the flat or bond pad portion of layer 60. This is because of the different conductivity of the thick copper-nickel-gold pads and traces compared to the thin gold on polymer bump 24. Consequently, metallization layer 26 may be between approximately 0.5 μm and 0.8 μm on polymer bump 24 when its thickness is approximately 3.0 μm elsewhere. It is possible, therefore, to optimize the gold thicknesses for a mixed technology assembly, while at the same time maintaining the thin layer on polymer bump 24 that is necessary for compliancy. In the present embodiment, for example, metallization layer 26 is selected to be sufficiently thick to provide electrical connectivity from substrate bond pad 20 to the top surface 14 (FIG. 1), while, at the same time to be sufficiently thin so as not to offset the compliancy and flexibility of polymer bump 24.⁶

From the drawing figures and the description above, it is clear that the element 26 consists two layer of gold metallization – layer 60 by electroless plating and layer 62 by electroplating. Nolan does disclose that the plating rate on the

⁵ US 5,508,228 col. 9, ll. 58-67.

⁶ Ibid, col. 10, ll. 15-37.

polymer bump being slower than the plating rate on the flat or bond pad portion of layer 60; however, it does not disclose a different plating rate on the sidewall of the polymer bump. Therefore, it does not disclose the thickness of the layer 26 on the top of the polymer bump (the inner portion) to be thinner than the sidewall of the polymer bump (the outer portion). For the same reason as presented related to claim 1 above, the polymer bump does not contact the flat portion of the contact plate, it can not be said that the structure of the Nolan patent discloses a compliant layer contacting both the thin portion and the thick portion of the contact pad, as required in claim 30 of this application.

Because the Nolan patent does not disclose or suggest all the claim elements in claim 30, applicant respectfully submits that it does not render claim 30 obvious and claim 30 stands patentable over the Nolan patent.

Claims 31-33

Claims 31-33 properly depend from claim 30. Because claim 30 stands patentable over the cited references, applicant respectfully submits that claims 31-33 must also stand patentable at least by virtue of their dependence.

Applicant respectfully submits that this application is in allowable form and all pending claims distinguish over the cited references in the Office Action. Applicant respectfully requests further examination of this application and timely allowance of the pending claims.

Respectfully submitted,

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